

08/30/00
JCS35 U.S. PTO

LAW OFFICES
SUGHRUE, MION, ZINN, MACPEAK & SEAS, PLLC
2100 PENNSYLVANIA AVENUE, N.W.
WASHINGTON, DC 20037-3213
TELEPHONE (202) 293-7060
FACSIMILE (202) 293-7860
www.sughrue.com

JCS35 U.S. PTO
09/651096
08/30/00

August 30, 2000

BOX PATENT APPLICATION
Assistant Commissioner for Patents
Washington, D.C. 20231

Re: Application of Katsutoshi IWAMURA
CONTROL UNIT AND METHOD FOR CONTROLLING
MOTOR FOR USE IN PRINTER, AND STORAGE MEDIUM
STORING CONTROL PROGRAM
Our Ref. Q60668

Dear Sir:

Attached hereto is the application identified above including 31 pages of specification, claims and Abstract, 13 sheets of formal drawing (Figures 1-16). The executed Declaration/Power of Attorney and Assignment will be submitted at a later date. Also enclosed are the three (3) certified priority documents.

The Government filing fee is calculated as follows:

Total claims	23 - 20	=	3	x	\$18.00	=	\$54.00
Independent claims	9 - 3	=	6	x	\$78.00	=	\$468.00
Base Fee							\$690.00

TOTAL FILING FEE **\$1212.00**

A check for the statutory filing fee of \$1212.00 is attached. You are also directed and authorized to charge or credit any difference or overpayment to Deposit Account No. 19-4880. The Commissioner is hereby authorized to charge any fees under 37 C.F.R. §§ 1.16 and 1.17 and any petitions for extension of time under 37 C.F.R. § 1.136 which may be required during the entire pendency of the application to Deposit Account No. 19-4880. A duplicate copy of this transmittal letter is attached.

Priority is claimed from August 31, 1999, December 24, 1999, and June 5, 2000, based on Japanese Application Nos. 11-246209, 11-368019, and 2000-167763 respectively. The priority documents are enclosed herewith.

Respectfully submitted,
SUGHRUE, MION, ZINN,
MACPEAK & SEAS, PLLC
Attorneys for Applicant

By: Robert J. Seas, Jr.
Robert J. Seas, Jr.
Registration No. 21,092

CONTROL UNIT AND METHOD FOR CONTROLLING MOTOR FOR USE IN PRINTER,
AND STORAGE MEDIUM STORING CONTROL PROGRAM

BACKGROUND OF THE INVENTION

5 Field of The Invention

The present invention relates generally to a control unit and method for controlling a motor for use in a printer, and a storage medium storing a control program.

Description of Related Art

10 Conventionally, paper-feed control for printers is performed by controlling a paper-feed motor (called a PF motor hereinafter). Control of a PF motor using a DC(Direct Current) motor as the PF motor is performed as follows. The PF motor is started by acceleration control. The motor is then driven at a
15 constant speed by PID control, and decelerated to stop. PID control is performed based on a deviation of the number of output pulses of an encoder that rotates to follow the rotation of the PF motor from a target number of pulses (position).

PID control is, however, has following drawbacks: It is
20 difficult to precisely stop a PF motor at a target position. An actual position at which a PF motor stops may fall in an allowable range, however, is distant from the target position. The PF motor sometimes rotates a little bit after stoppage due to disturbance, such as, vibration of a carriage in serial printer.

25 In the event of paper-feed processing by starting a PF motor again after stoppage, since a target position for the motor is set with reference to the target position that has been set at a previous motor start-up before stoppage, printing medium (sheet of paper) may stop at a position further distant from the target
30 position. This results in printing at positions distant from desired positions.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to eliminate the aforementioned problems and to provide a control
35 unit, a method and also a storage medium storing a control program for controlling a motor for use in a printer, which offer precise positioning of a printing medium even the motor starts again after

stoppage.

The present invention provides A control unit for controlling a motor for use in a printer including: a position counter to count output pulses of an encoder that rotates to follow rotation of the motor and thereby detect a position of a printing medium transferred by the motor; a target control amount modifying and calculating part to calculate an modified target value of a feed-amount of the printing medium based on a target value of a feed-amount of the printing medium and a previous stop position of the printing medium detected by the position counter, and set a counted value of the position counter to the modified target value; and a position control part to control the motor so that the counted value of the position counter falls into a predetermined range including zero.

Moreover, the present invention provides a control unit for controlling a motor for use in a printer including: a position detecting part to detect a position of a printing medium transferred by the motor; a target position modifying and calculating part to calculate a modified target position of the printing medium based on a target value of a feed-amount of the printing medium at the present motor start-up, another target value of a feed-amount of the printing medium at a previous motor start-up, and a position of the printing medium detected by the position detecting part just before the present motor start-up; and a position control part to control the motor based on positional deviation of the position detected by the position detecting part from the modified target position.

The target position modifying and calculating part may include: an error calculating part to calculate an error of the feed-amount of the printing medium at the previous motor start-up based on a target value of a control amount at a previous motor start-up and the position detected by the position detecting part just before the present motor start-up; and an adder to add the target value of a feed-amount of the printing medium at the present motor start-up and the error.

Furthermore, the present invention provides a control method of controlling a motor for use in a printer including the

steps of: counting output pulses of an encoder that rotates to follow rotation of the motor and detecting a position of a printing medium transferred by the motor by a position counter; calculating a modified target value of a feed-amount of the printing medium based on a target value of a feed-amount of the printing medium and a previous stop position of the printing medium detected by the position counter, and setting a counted value of the position counter to the modified target value; and controlling the motor so that the counted value of the position counter falls into a predetermined range including zero.

The step of controlling may perform PID control.

The position counter may count-up or count-down the output pulses according a normal or reverse rotation of the motor.

Moreover, the present invention provides a method of controlling a motor for use in a printer including the steps of: detecting a position of a printing medium transferred by the motor; calculating a modified target position value of the printing medium based on a target value of a feed-amount of the printing medium at the present motor start-up, another target value of a feed-amount of the printing medium at a previous motor start-up, and a position of the printing medium detected just before the present motor start-up; and controlling the motor based on positional deviation of the position detected by the position detecting part from the modified target position.

Furthermore, the present invention provides a processor readable medium storing program code for causing a computer to control a motor for use in a printer including: first program code means for, by a position counter, counting output pulses of an encoder that rotates to follow rotation of the motor to detect a position of a printing medium transferred by the motor; second program code means for modifying and calculating part to calculate a modified target value of a feed-amount of the printing medium based on a target value of a feed-amount of the printing medium and a previous stop position of the printing medium detected by the position counter, and setting a counted value of the position counter to the modified target value; and third program code means for controlling the motor so that the counted

value of the position counter falls into a predetermined range including zero.

Moreover, the present invention provides a processor readable medium storing program code for causing a computer to control a motor for use in a printer including: first program code means for detecting a position of a printing medium transferred by the motor; second program code means for calculating a modified target position of the printing medium based on a target value of a feed-amount of the printing medium at the present motor start-up, another target value of a feed-amount of the printing medium at a previous motor start-up, and a position of the printing medium detected just before the present motor start-up; and third program code means for controlling the motor based on positional deviation of the detected position of the printing medium from the modified target position.

Still furthermore, the present invention provides a control unit for controlling a motor for use in a printer including: a position counter to detect a position of a sheet of paper transferred by a paper-feed motor based on output pulses of an encoder that rotates to follow rotation of the paper-feed motor; a driving part to apply a current value to the paper-feed motor based on a target value of a feed-amount of the sheet of paper and an output of the position counter, to drive the paper-feed motor; a current value signal generating part to determine whether the absolute value of deviation of the output of the position counter from the target value of the feed-amount of the sheet of paper falls in the range of a first predetermined value to a second predetermined value smaller than the first predetermined value during stoppage of the paper-feed motor, to generate a current value signal, when the absolute value of deviation falls in the range, so that the deviation becomes zero, wherein the driving part drives the paper-feed motor based on the current value signal.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be understood more fully from

the detailed description given herebelow and from the accompanying drawings of the preferred embodiments of the invention. However, the drawings are not intended to imply limitation of the invention to a specific embodiment, but are 5 for explanation and understanding only.

In the drawings:

FIG. 1 is a block diagram showing the construction of the first preferred embodiment of a control unit for controlling a motor for use in a printer according to the present invention;

10 FIG. 2 shows waveforms explaining the operation of the first preferred embodiment of a control unit for controlling a motor for use in a printer;

FIG. 3 is a block diagram showing the construction of the second preferred embodiment of a control unit for controlling 15 a motor for use in a printer according to the present invention;

FIG. 4 is a block diagram showing an example of a target position modifying and calculating part according to the present invention;

20 FIG. 5 is a block diagram schematically showing the construction of an ink jet printer;

FIG. 6 is a perspective view showing the peripheral construction of a carriage;

FIG. 7 is a schematic view showing the construction of a linear type encoder;

25 FIGS. 8(a) and 8(b) are waveform illustrations of output pulses of an encoder;

FIG. 9 is a schematic perspective view of a printer for explaining the position of a paper detecting sensor;

30 FIG. 10 is a flow chart showing a control procedure in a method for controlling a motor for use in a printer according to the present invention;

FIG. 11 is a flow chart showing another control procedure in a method for controlling a motor for use in a printer according to the present invention;

35 FIG. 12 is a perspective view showing an example of a computer system using a storage medium, in which a print control program has been recorded, according to the present invention;

FIG. 13 is a block diagram showing an example of a computer system using a storage medium, in which a print control program has been recorded, according to the present invention;

5 FIG. 14 is a block diagram showing the construction of the seventh preferred embodiment of a control unit for controlling a motor for use in a printer according to the present invention;

FIG. 15 is a flow chart explaining the operation of the seventh preferred embodiment; and

10 FIG. 16 is a flow chart explaining the operation of a modification of the seventh preferred embodiment.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the accompanying drawings, the preferred embodiments of the present invention will be described below.

15 First, the schematic construction and control of an ink jet printer, which uses a control unit for controlling a motor for use in a printer according to the present invention, will be described. The schematic construction of this ink jet printer is shown in FIG. 5.

20 This ink jet printer comprises: a paper feed motor (which will be also hereinafter referred to as a PF motor) 1 for feeding a sheet of paper; a paper feed motor driver 2 for driving the paper feed motor 1; a carriage 3; a carriage motor (which will be also hereinafter referred to as a CR motor) 4; a CR motor driver
25 5 for driving the carriage motor 4; a DC unit 6; a pump motor 7 for controlling the suction of ink for preventing clogging; a pump motor driver 8 for driving the pump motor 7; a recording head 9, fixed to the carriage 3, for discharging ink to a printing paper 50; a head driver 10 for driving and controlling the
30 recording head 9; a linear type encoder 11 fixed to the carriage 3; a code plate 12 which has slits in regular intervals; a rotary type encoder 13 for use in the PF motor 1; a paper detecting sensor 15 for detecting the position of the rear edge of a paper which is being printed; a CPU 16 for controlling the whole printer;
35 a timer IC 17 for periodically generating an interruption signal to output the signal to the CPU 16; an interface part (which will be also hereinafter referred to as an IF) 19 for

transmitting/receiving data to/from a host computer 18; an ASIC 20 for controlling the printing definition, the driving waveform of the recording head 9 and so forth on the basis of printing information which is fed from the host computer 18 via the IF 19; a PROM 21, RAM 22 and EEPROM 23 which are used as working and program storing regions for the ASIC 20 and the CPU 16; a platen 25 for supporting the paper 50 during print; a carrier roller 27, driven by the PF motor 1, for carrying the printing paper 50; a pulley 30 mounted on the rotating shaft of the CR motor 4; and a timing belt 31 driven by the pulley 30.

Furthermore, the DC unit 6 is designed to drive and control the paper feed motor driver 2 and the CR motor driver 5 on the basis of a control command, which is fed from the CPU 16, and the outputs of the encoders 11 and 13. In addition, each of the paper feed motor 1 and the CR motor 4 comprises a DC motor.

The peripheral construction of the carriage 3 of this ink jet printer is shown in FIG. 6.

The carriage 3 is connected to the carriage motor 4 via the timing belt 31 and the pulley 30 to be driven so as to be guided by a guide member 32 to move in parallel to the platen 25. The carriage 3 is provided with the recording head 9 on the surface facing the printing paper. The recording head 9 comprises a nozzle row for discharging a black ink and a nozzle row for discharging color inks. Each nozzle is supplied with ink from an ink cartridge 34, and discharges drops of ink to the printing paper to print characters and/or images.

In a non-print region of the carriage 3, there are provided a capping unit 35 for sealing a nozzle opening of the recording head 9 during non-print, and a pump unit 36 having the pump motor 7 shown in FIG. 5. When the carriage 3 moves from a print region to the non-print region, the carriage 3 contacts a lever (not shown) to move the capping unit 35 upwards to seal the recording head 9.

When the nozzle opening row of the recording head 9 is clogged with ink, or when the cartridge 34 is exchanged or the like to force the recording head 9 to discharge ink, the pump unit 36 is operated in the sealed state of the recording head

9, to suck ink out of the nozzle opening row by a negative pressure from the pump unit 36. Thus, dust and paper powder adhering to a portion near the nozzle opening row are cleaned. Moreover, bubbles of the recording head 9, together with ink, are discharged to a cap 37.

Then, the construction of the linear type encoder 11 mounted on the carriage 3 is shown in FIG. 7. This encoder 11 comprises a light emitting diode 11a, a collimator lens 11b, and a detection processing part 11c. The detection processing part 11c has a plurality of (four) photodiodes 11d, a signal processing circuit 11e, and two comparators 11f_A and 11f_B.

If a voltage V_{CC} is applied between both ends of the light emitting diode 11a via a resistor, light rays are emitted from the light emitting diode 11a. The light rays are collimated by the collimator lens 11b to pass through the code plate 12. The code plate 12 is provided with slits at regular intervals (e.g., every 1/180 inches (= 1/180 x 2.54 cm)).

The parallel rays passing through the code plate 12 are incident on each of the photodiodes 11d via a fixed slit (not shown), and converted into electric signals. The electric signals outputted from the four photodiodes 11d are processed by the signal processing circuit 11e. The signals outputted from the signal processing circuit 11e are compared by the comparators 11f_A and 11f_B, and the compared results are outputted as pulses. The pulses ENC-A and ENC-B outputted from the comparators 11f_A and 11f_B are outputs of the encoder 11.

The phase of the pulse ENC-A is different from the phase of the pulse ENC-B by 90 degrees. The encoder 4 is designed so that the phase of the pulse ENC-A is advanced from the pulse ENC-B by 90 degrees as shown in FIG. 8(a) when the CR motor 4 is normally rotating, i.e., when the carriage 3 is moving a main scanning direction, and the phase of the pulse ENC-A lags behind the pulse ENC-B by 90 degrees as shown in FIG. 8(b) when the CR motor 4 is reversely rotating. One period T of the pulses corresponds to the distance between adjacent slits of the code plate 12 (e.g., 1/180 inches (= 1/180 x 2.54 cm)). This is equal to a period of time, in which the carriage 3 moves between the adjacent slits.

On the other hand, the rotary type encoder 13 for use in the PF motor 1 has the same construction as that of the linear type encoder 11, except that the code plate is a rotating disk which rotates in accordance with the rotation of the PF motor 1. Furthermore, in the ink jet printer, the distance between adjacent slits of a plurality of slits provided in the code plate of the encoder 13 for use in the PF motor is $1/180$ inches ($1/180 \times 2.54$ cm). When the PF motor 1 rotates by the distance between adjacent slits, the paper is fed by $1/1440$ inches ($= 1/1440 \times 2.54$ cm).

Referring to FIG. 9, the position of the paper detecting sensor 15 shown in FIG. 5 will be described below.

In FIG. 9, the paper 10 inserted into a paper feeding port 61 of a printer 60 is fed into the printer 60 by means of a paper feeding roller 64 which is driven by a paper feeding motor 63. The front edge of the paper 50, which has been fed into the printer 60, is detected by, e.g., an optical paper detecting sensor 15. The paper 50, the front edge of which has been detected by the paper detecting sensor 15, is fed by means of a paper feed roller 65 and a driven roller 66 which are driven by the PF motor 1.

Subsequently, ink drops from the recording head (not shown), which is fixed to the carriage 3 moving along the carriage guide member 32, to carry out a print. Then, when the paper is fed to a predetermined position, the rear edge of the paper 50, which is currently being printed, is detected by the paper detecting sensor 15. Then, a gear 67c is driven, via a gear 67b, by means of a gear 67a which is driven by the PF motor 1. Thus, a paper discharging roller 68 and a driven roller 69 are rotated to discharge the printed paper 50 from a paper discharging port 62 to the outside.

(First Preferred Embodiment)

The construction of the first preferred embodiment of a control unit for controlling a motor for use in a printer according to the present invention will be described below. Control of a motor use in a printer is performed by a DC unit 6 shown in FIG. 5 and its construction is shown in FIG. 1.

A control unit for controlling a motor for use in a printer

according to the present invention, that is, the DC unit 6 comprises a position counter 6a, a subtracter 6b, a target speed calculating part 6c, a speed calculating part 6d, a subtracter 6e, a proportional element 6f, an integrating element 6g, a
5 differentiating element 6h, an adder 6i, a D/A converter 6j, a timer 6k, an acceleration control part 6m, and a feed-amount modifying/calculating part 90.

The position counter 6a is designed to detect the leading and trailing edges of each of the output pulses ENC-A and ENC-B
10 of the encoder 13 to count the number of the detected edges, and to calculate the rotary position of the PF motor 1 on the basis of the counted value. In this counting, when the PF motor 1 is normally rotating, if one edge is detected, "+1" is added, and when the PF motor 1 is reversely rotating, if one edge is detected,
15 "-1" is added. Each of the periods of the pulses ENC-A and ENC-B is equal to the distance between adjacent slits of a code plate of the encoder 13, and the phase of the pulse ENC-A is different from the phase of the pulse ENC-B by 90 degrees. Therefore, the counted value "1" in the above described counting corresponds to
20 1/4 of the distance between adjacent slits of the code plate of the encoder 13. Thus, if the counted value is multiplied by 1/4 of the distance between adjacent slits, it is possible to obtain the moving amount of the PF motor 1 from a position corresponding to a counted value "0".

The feed-amount modifying/calculating part 90 operates based on a start-up command signal for starting the PF motor 1 fed from the CPU 16, to calculate a modified paper-feed amount based on a start-up target position "0" and the counted value (the number of pulses) of the position counter 6a just after
30 receiving the start-up command signal, or a previous stop position. The modified paper-feed amount is fed to the position counter 6a for setting a counted value so that it corresponds to the modified paper-feed amount. The nearer to the target position, the smaller the counted value being set for the position counter
35 6a.

The subtracter 6b is designed to calculate a position deviation of the counted value of the position counter 6a, from

the target position "0".

The target speed calculating part 6c is designed to calculate a target speed of the PF motor 1 on the basis of the position deviation which is the output of the subtracter 6b. This operation is carried out by multiplying the position deviation by a gain K_p . This gain K_p is determined in accordance with the position deviation. Furthermore, the value of the gain K_p may be stored in a table (not shown).

The speed calculating part 6d is designed to calculate a speed of the PF motor 1 on the basis of the output pulses ENC-A and ENC-B of the encoder 13. This speed is obtained as follows. First, the leading and trailing edges of each of the output pulses ENC=A and ENC=B of the encoder 13 are detected, and the time interval between the edges is counted by, e.g., a timer counter. Assuming that the counted value is T, the speed of the PF motor 1 is proportional to $1/T$. Furthermore, in this preferred embodiment, the speed of the PF motor is obtained by counting one period of the output pulse ENC-A, e.g., the period between the leading edge and the next leading edge, by means of a timer counter.

The subtracter 6e is designed to calculate a speed deviation of the actual speed of the PF motor 1, which is calculated by the speed calculating part 6d, from a target speed.

The proportional element 6f is designed to multiply the speed deviation by a constant G_p to output the multiplied result. The integrating element 6g is designed to integrate a value which is obtained by multiplying the speed deviation by a constant G_i . The differentiating element 6h is designed to multiply a difference between the current speed deviation and the last speed variation by a constant G_d to output the multiplied result. Furthermore, the operations in the proportional element 6f, integrating element 6g and differentiating element 6h are carried out every one period of the output pulse ENC-A of the encoder 13, i.e., in synchronism with the leading edge of the output pulse ENC-A.

The outputs of the proportional element 6f, integrating element 6g and differentiating element 6h are added by the adder

6i. Then, the added result, i.e., the driving current of the PF motor 1, is fed to the D/A converter 6j to be converted into an analog current. On the basis of the analog current, the PF motor 1 is driven by the paper-feed driver 2.

5 In addition, the timer 6k and the acceleration control part 6m are used for controlling acceleration, and the PID control using the proportional element 6f, integrating element 6g and differentiating element 6h is used for controlling the constant speed and deceleration during acceleration.

10 The timer 6k is designed to generate a timer interruption signal every a predetermined time on the basis of a clock signal which is fed from the CPU 16.

The acceleration control part 6m is designed to integrate a predetermined current value (e.g., 20 mA) into a target current value every time it receives the timer interruption signal, and to feed the integrated result, i.e., the target current value of the PF motor 1 during acceleration, to the D/A converter 6j. Similar to the PID control, the target current value is converted into an analog current by the D/A converter 6j. On the basis of this analog current, the PF motor 1 is driven by the driver 2.

15
20

The driver 2 has, e.g., four transistors. By turning each of the transistors ON and OFF on the basis of the output of the D/A converter 6j, the driver 2 can be selectively in (a) an operation mode in which the PF motor 1 is normally or reversely rotated, (b) a regenerative brake operation mode (a short brake operation mode, i.e., a mode in which the stopping of the PF motor 1 is maintained), or (c) a mode in which the PF motor 1 is intended to be stopped.

25

Referring to FIGS. 2(a) and 2(b), the operation of the DC unit 6, that is, the control unit for controlling a motor for use in a printer, will be described below.

30

If a start-up command signal for starting the PF motor 1 is fed from the CPU 16 to the DC unit 6 when the PF motor 1 is stopped,

35 a modified paper-feed amount is calculated by the feed-amount modifying/calculating part 90, and is set as a counted value of the position counter 6a, during which a start-up initial current

value I_0 is fed from the acceleration control part 6m to the D/A converter 6j. This start-up initial current value I_0 , together with the start-up command signal, is fed from the CPU 16 to the acceleration control part 6m. Then, this current value I_0 is converted into an analog current by the D/A converter 6j to be fed to the driver 2, and the PF motor 1 is started up by the driver 2 (see FIG. 2(a), 2(b)).

After the start-up command signal is received, the timer 6k generates a timer interruption signal every a predetermined time. Every time the acceleration control part 6m receives the timer interruption signal, the acceleration control part 6m integrates a predetermined current value (e.g., 20 mA) into the start-up initial current value I_0 , to feed the integrated current value to the D/A converter 6j. Then, the integrated current value is converted into an analog current by the D/A converter 6j to be fed to the driver 2. Then, the PF motor 1 is driven by the driver 2 so that the value of the current supplied to the PF motor 1 is the integrated current value, so that the speed of the PF motor 1 increases (see FIG. 2(b)). Therefore, the current value supplied to the PF motor 1 is step-wise as shown in FIG. 2(a).

Furthermore, at this time, although the PID control system also operates, the D/A converter 6j selects and incorporates the output of the acceleration control part 6m.

The integration of the current value in the acceleration control part 6m is carried out until the integrated current value becomes a constant current value I_s . When the integrated current value becomes the predetermined value I_s at time t_1 , the acceleration control part 6m stops the integration, and supplies the constant current value I_s to the D/A converter 6j. Thus, the PF motor 1 is driven by the driver 2 so that the value of the current supplied to the PF motor 1 becomes the current value I_s (see FIG. 2(a)).

Then, in order to prevent the speed of the PF motor 1 from overshooting, the acceleration control part 6m controls the PF motor 1 so as to reduce the current, which is supplied to the PF motor 1, when the speed of the PF motor 1 becomes a predetermined speed V_1 (see time t_2). At this time, the speed of the PF motor

1 further increases. However, when the speed of the PF motor 1 reaches a predetermined speed V_c (see time t_1 in FIG. 2(b)), the D/A converter 6j selects the output of the PID control system, i.e., the output of the adder 6i, to carry out the PID control.

5 That is, the target speed is calculated on the basis of the position deviation of the counted value of the counter 6a from the target position "0". In addition, the proportional element 6f, integrating element 6g and differentiating element 6h are operated on the basis of the speed deviation of the actual
10 speed, which is obtained from the output of the encoder 13, from the target speed to carry out the proportional, integrating and differentiating operations. Moreover, the PF motor 1 is controlled on the basis of the sum of these calculated results. Furthermore, the above described proportional, integrating and
15 differentiating operations are carried out in synchronism with, e.g., the leading edge of the output pulse ENC-A of the encoder 13. Thus, the speed of the PF motor 1 is controlled so as to be a desired speed V_o . Furthermore, the predetermined speed V_c is preferably a value of 70 % to 80 % of the desired speed V_o .

20 The speed of the PF motor 1 reaches the desired speed V_o after time t_4 . When the PF motor 1 reaches the target position (see time t_5 in FIG. 2(b)), the PF motor 1 is decelerated to be stopped at time t_6 .

As disclosed above, according to the present invention,
25 a paper-feed amount at the present start-up is modified by the feed-amount modifying/calculating part 90 based on the present target feed-amount and the counted value of the position counter 6a just after receiving a start-up command signal, or a previous stop position, the modified paper-feed amount being set as a
30 counted value of the position counter 6a for paper-feed control based on the deviation of the output of the position counter 6a and the target value "0".

The paper-feed control according to the present invention thus offers precise paper feeding so that a sheet of paper is
35 stopped at a target position. The target value is not only "0", but preferably falls in the range from -3 to +3 including "0".

The maximum counted value of the position counter 6a

corresponds to a modified paper-feed amount in this embodiment, thus requiring a small capacity for the position counter 6a. (Second Preferred Embodiment)

5 The construction of the second preferred embodiment of a control unit for controlling a motor for use in a printer according to the present invention will be described below.

Control of a motor for use in a printer according to this embodiment is performed by a DC unit 6 shown in FIG. 5 the construction of which is shown in FIG. 3.

10 The control unit for controlling a motor for use in a printer according to this embodiment, that is, the DC unit 6 corresponds to the control unit for controlling a motor for use in a printer according to the first embodiment, but having a target position modifying/calculation part 80.

15 The target position modifying/calculation part 80 operates based on a start-up command signal for starting the PF motor 1 fed from the CPU 16, to calculate a modified target position based on a target feed-amount (the number of pulses) at a previous PF motor start-up, a target feed-amount (the target number of pulses)
20 at the present PF motor start-up, and the counted value (the number of pulses) of the position counter 6a just after receiving the start-up command signal. The calculation result is fed to the subtracter 6b.

25 An example of the construction of the target position modifying/calculation part 80 is shown in FIG. 4.

The target position modifying/calculation part 80 is provided with a memory 81, an error calculating part 82, an adder 83 and a reset signal generating part 84.

30 The memory 81 feeds the stored target feed-amount at a previous PF motor start-up to the error calculating part 82 based on the start-up command signal, and stores the target feed-amount at the present PF motor start-up fed from the CPU 16, in place of the target feed-amount that has been stored.

35 The error calculating part 82 calculates an error, that is, the difference between the target feed-amount at the previous PF motor start-up fed from the memory 81 and the counted value (the number of pulses) of the counter 6a just after receiving

the start-up command signal. The error is fed to the adder 83 and also to the reset signal generating part 84 that generates a reset signal for resetting the start-up command. The error is a positive or negative value.

5 The adder 83 adds the error and the target position (target feed-amount) at the present PF motor start-up fed from the CPU 16, to generate the addition result as a target position.

 The reset signal generating part 84 that generates a reset signal to reset the counted value of the position counter 6a to
10 "0". The reset signal generating part 84 may generate a reset signal based on the output of the adder 83 instead of a command signal from the error calculating part 82.

 The subtracter 6b calculates the positional deviation of an actual position of the PF motor 1 calculated by the position
15 counter 6a from a modified target position fed by the target position modifying/calculation part 80. Paper-feed control is performed like the first embodiment so that the deviation becomes zero.

 As disclosed, according to this embodiment, the target
20 position modifying/calculation part 80 modifies the target position at the present PF motor start-up based on the target position and the counted value of the position counter 6a just after receiving the start-up command signal for paper-feed control based on the positional deviation of the output of the
25 position counter 6a from the modified target value, thus achieving precise paper feeding.

 The first and the second embodiments are disclosed as applied to an ink jet printer, however, can be applied to other printers, such as, a serial printer and a laser printer. Moreover,
30 the first and the second embodiments are disclosed using a DC motor, however, can use an AC motor. Furthermore, the first and the second embodiments are disclosed using a sheet of paper as a printing medium, however, can use other printing media.
(Third Preferred Embodiment)

35 The third preferred embodiment according to the present invention will be described with reference to FIG. 10. The third embodiment is a method of controlling a motor for use in a printer

the control procedure of which is shown in FIG. 10.

Output pulses of an encoder that rotates to follow the rotation of a PF motor are counted by a position counter to detect a position of a printing medium (a sheet of paper) transferred by the PF motor (see step F10 in FIG. 10). Calculated next is an modified target feed-amount based on a target printing medium-feed amount and a previous stop position of the printing medium detected by the position counter, the modified target feed-amount being set to a counted value of the position counter (see step F11 in FIG. 10). The PF motor is then controlled so that the counted value of the position counter falls into a predetermined range including zero (see step F12 in FIG. 10).

The control method as disclosed above is capable of stopping a printing medium at a target position, thus achieving precise paper feeding.
(Fourth Preferred Embodiment)

The fourth preferred embodiment according to the present invention will be described with reference to FIG. 11. The fourth embodiment is a method of controlling a motor for use in a printer the control procedure of which is shown in FIG. 11.

A position of a printing medium (a sheet of paper) transferred by a PF motor is detected (see step F20 in FIG. 11). Calculated next is a modified target position of the printing medium based on a target printing medium feed-amount at the present PF motor start-up, a target printing medium feed-amount at a previous PF motor start-up, and a detected position of the printing medium just before the present PF motor start-up (see step F21 in FIG. 11). The PF motor is then controlled based on the deviation of the detected position of the printing medium from the modified target position (see step F21 in FIG. 11).

The control method as disclosed above thus achieves precise paper feeding.

The step of calculating a modified target position may further includes the step of calculating an error of the printing medium feed-amount after the previous PF motor start-up based on the target printing medium-feed amount at the previous PF motor start-up and the detected position of the printing medium just

before the present PF motor start-up, and the step of calculating the modified target position by adding the target printing medium feed-amount at the present motor start-up and the error.

(Fifth Preferred Embodiment)

5 Referring to FIGS. 12 and 13, the fifth preferred embodiment of the present invention will be described below. This preferred embodiment relates to a storage medium, in which a control program for controlling a motor for use in a printer has been stored. FIGS. 12 and 13 are a perspective view and block
10 diagram showing an example of a computer system 130 which uses a storage medium, in which a print control program in this preferred embodiment has been recorded.

In FIG. 12, the computer system 130 comprises a computer body 130 including a CPU, a display unit 132, such as a CRT, an
15 input unit 133, such as a keyboard or mouse, and a printer 134 for carrying out a print.

As shown in FIG. 13, the computer body 131 comprises an internal memory 135 of a RAM, and a built-in or exterior memory unit 136. As the memory unit 136, a flexible or floppy disk (FD) drive 137, a CD-ROM drive 138 and a hard disk drive (HD) unit
20 139 are mounted. As shown in FIG. 12, a flexible disk or floppy disk (FD) 141 which is inserted into a slot of the FD drive 137 to be used, a CD-ROM 142 which is used for the CD-ROM drive 138, or the like is used as a storage medium 140 for use in the memory unit 136.
25

As shown in FIGS. 12 and 13, it is considered that the FD 141 or the CD-ROM 142 is used as the storage medium for use in a typical computer system. However, since this preferred embodiment relates to a control program for controlling a motor
30 for use in the printer 134, the control program of the present invention may be recorded in, e.g., a ROM chip 143 serving as a nonvolatile memory which is built in the printer 134. Of course, the storage medium may be any one of FDs, CD-ROMs, MOs (Magneto-Optical) disks, DVDs (Digital Versatile Disks), other
35 optical recording disks, card memories, and magnetic tapes.

The storage medium 140 in this preferred embodiment is designed to carry out a control procedure including steps F10

through F12 shown in FIG. 10. That is, the storage medium 140 in this preferred embodiment may carry out the steps of, at least, detecting a position of a printing medium transferred by a motor by a position counter by counting output pulses of an encoder
5 that rotates to follow the rotation of the motor, calculating a modified target feed-amount value based on a target printing medium feed-amount and a previous stop position of the printing medium detected by the position counter, and setting an counted value of the position counter to the modified target value, and
10 controlling the motor so that the counted value of the position counter falls into a predetermined range including zero.
(Sixth Preferred Embodiment)

The sixth preferred embodiment of the present invention will be described below. This preferred embodiment relates to
15 a storage medium, in which a control program for controlling a motor for use in a printer has been stored. The control program includes the steps of F20 to F22 shown in FIG. 11.

The storage medium according to this embodiment may store, at least, the program code of detecting a position of a printing medium transferred by a motor, the program code of calculating
20 a modified target position of the printing medium based on a target feed-amount value of the printing medium at the present motor start-up, a target feed-amount value of the printing medium at a previous motor start-up, and a detected position of the printing medium just before the previous motor start-up, and the program
25 code of controlling the motor based on the deviation of the detected position of the printing medium from the modified target position.

The program code of calculating the modified target
30 position of the printing medium may at least includes the step of calculating an error of the feed-amount after the previous motor start-up based on the target feed-amount value at the previous motor start-up and the detected valued of the printing medium just before the present motor start-up, and the step of
35 calculating the modified target position by adding the target feed-amount value at the present motor start-up and the error.

As disclosed, the present invention achieves precise

stoppage of a printing medium even a motor for transferring the printing medium is started again after stoppage.

(Seventh Preferred Embodiment)

The control unit for controlling a motor for use in a printer according to the first embodiment offers precise paper feeding. However, this embodiment has a drawback in that printing at an accurate position would not be expected, when the original position "0" of the paper 50 varies, for example, caused by pulling the paper by a user, after stoppage even though no paper feed-command (start-up command) is received.

Such a problem is overcome by the seventh embodiment which will be disclosed below.

The seventh embodiment is disclosed with reference to FIGS. 14 and 15. FIG. 14 shows a block diagram of a control unit for controlling a motor for use in a printer according to this embodiment. FIG. 15 shows a flow chart explaining the operation of the control unit according to this embodiment.

The difference between the control units 6 according to the first and the seventh embodiments are that the latter unit includes a current value signal generating part 6p and a paper delivery processing part 6q. The other parts are the same between the two embodiments, and the explanation of those is omitted here because they have been explained in the first embodiment.

The current value signal generating part 6p determines whether the absolute value of the positional deviation output by the subtracter 6b falls in the range from a predetermined value N_1 and another predetermined value N_2 ($< N_1$) while the PF motor 1 is being stopped. If the absolute value falls in the range, the current value signal generating part 6p generates a current value signal that resets the deviation to "0". The current value signal is fed to the D/A converter 6j. On the other hand, paper delivery processing is performed if the absolute value is larger than the predetermined value N_1 . Or, the control processing ends if the absolute value is equal to or smaller than the predetermined value N_2 .

The paper delivery processing part 6q feeds a current values signal required for paper delivery to the D/A converter 6j when

it receives a paper delivery command from the current value signal generating part 6p.

The predetermined value N_2 is set, for example, to $1/1440$ inches ($= 1/1440 \times 2.54$ cm), that is, the value corresponding to one cycle of the output pulse ENC-A of the encoder 13. In general, a motor for use in a printer stops within a range of positional deviation $\pm 11/5760$ inches ($= 11/5760 \times 2.54$ cm) because it is difficult to stop the motor at a position where the positional deviation is zero. The value N_2 in this embodiment is set to the value smaller than the positional deviation in general.

On the other hand, the predetermined value N_1 is set, for example, to $22/1440$ inches ($= 22/1440 \times 2.54$ cm). This is because paper feeding in the direction that is the reverse of a paper delivery direction would cause lifting-up of a locking lever of a carriage connected to a paper-feed motor so that the carriage would collide with the locking lever when flashing or capping, and also cause jamming of sheets of paper that have been released from a paper feeder and transferred in the reverse direction with no places to be transferred, thus there is a limit for paper feeding in the reverse direction.

The predetermined values N_1 and N_2 can be varied according to the type of sheets of paper (thickness and surface friction coefficient, etc.) and the number of usage.

The operation of the current value signal generating part 6p is disclosed with reference to FIG. 15.

Assumption is made that the PF motor 1 stops after starting-up.

The current value signal generating part 6p determines whether the absolute value of the positional deviation output by the subtracter 6b is equal to or smaller than the predetermined value N_1 (see step F1 in FIG. 15). The current value signal generating part 6p feeds a paper delivery command to the paper delivery processing part 6q if the absolute is larger than the predetermined value N_1 . The paper delivery processing part 6q then feeds a current value signal required for paper delivery to the D/A converter 6j to start the PF motor 1 for paper delivery

processing based on the current value signal (see step F2 in FIG. 15).

On the other hand, if the absolute of the positional deviation is equal to or smaller than the predetermined value N_1 , the current value signal generating part 6p further determines whether the absolute value is equal to or smaller than the predetermined value N_2 (see step F3 in FIG. 15). If so, the processing ends; while if not, or the absolute value is larger than the predetermined value N_2 , the current value signal generating part 6p feeds a current value signal to the D/A converter 6j so that the positional deviation becomes zero (see step F4 in FIG. 15). The PF motor 1 then starts based on the current values signal and is controlled so that the positional deviation becomes zero (see step F5 in FIG. 15).

According to this control method, the original position for printing returns to the position before deviation, thus achieving printing at accurate positions.

The current value signal generating part 6p operates based on the output of the subtracter 6b in this embodiment, however, it may operate based on the output of the position counter 6a.

Moreover, the paper delivery processing is performed in this embodiment when the absolute value of the positional deviation is larger than the predetermined value N_1 , however, printing can be performed with a deviated position as the original position with no paper delivery processing.

Furthermore, the absolute value of the positional deviation is firstly compared with the predetermined value N_1 and then compared with the predetermined value N_2 , however, it can be compared with the predetermined value N_2 firstly and then compared with the predetermined value N_1 , as indicated by the flow chart shown in FIG. 16. The steps F1 and F3 in FIG. 15 are reversed in FIG. 16.

As disclosed above, according to this embodiment, the original position for printing can be returned to the original even if deviated after the PF motor stops, thus achieving continuous printing at accurate positions. This embodiment also has the same advantages for the first embodiment.

Moreover, this embodiment has been disclosed using a DC motor as the PF motor 1, however, can use an AC motor with the same advantages.

(Eighth Preferred Embodiment)

5 The eighth preferred embodiment of the present invention will be described below. This preferred embodiment relates to a storage medium, in which a control program for controlling a motor for use in a printer has been stored. The control program includes the steps of F1 to F5 shown in FIG. 15 or 16.

10 The storage medium according to this embodiment may store, at least, the program code of obtaining the deviation of an actual feed-amount of a sheet of paper calculated based on output pulses of an encoder that rotates to follow the rotation of a paper-feed motor from a target paper feed-amount value at a previous motor
15 start-up while motor is stopping, the program code of determining whether the absolute value of the deviation falls in a range between a first predetermined value and a second predetermined value smaller than the first predetermined value, the program code of generating a current value signal so that the deviation
20 becomes zero when the absolute value of the deviation is judged as falling in the range, and the program code of controlling the motor based on the current value signal.

 While the present invention has been disclosed in terms of the preferred embodiment in order to facilitate better
25 understanding thereof, it should be appreciated that the invention can be embodied in various ways without departing from the principle of the invention. Therefore, the invention should be understood to include all possible embodiments and modification to the shown embodiments which can be embodied
30 without departing from the principle of the invention as set forth in the appended claims.

WHAT IS CLAIMED IS:

1. A control unit for controlling a motor for use in a printer comprising:

a position counter to count output pulses of an encoder that rotates to follow rotation of the motor, and thereby detect a position of a printing medium transferred by the motor;

a target control amount modifying and calculating part to calculate a modified target value of a feed-amount of the printing medium based on a target value of a feed-amount of the printing medium and a previous stop position of the printing medium detected by the position counter, and set a counted value of the position counter to the modified target value; and

a position control part to control the motor so that the counted value of the position counter falls into a predetermined range including zero.

2. A control unit for controlling a motor for use in a printer, as set forth in claim 1, wherein the printing medium is a paper and the motor is a paper-feed motor.

3. A control unit for controlling a motor for use in a printer, as set forth in claim 1, wherein the position control part performs PID control.

4. A control unit for controlling a motor for use in a printer, as set forth in claim 1, wherein the position counter counts-up or counts-down the output pulses according a normal or reverse rotation of the motor.

5. A control unit for controlling a motor for use in a printer comprising:

a position detecting part to detect a position of a printing medium transferred by the motor;

a target position modifying and calculating part to calculate a modified target position of the printing medium based on a target value of a feed-amount of the printing medium at the

present motor start-up, another target value of a feed-amount of the printing medium at a previous motor start-up, and a position of the printing medium detected by the position detecting part just before the present motor start-up; and

a position control part to control the motor based on positional deviation of the position detected by the position detecting part from the modified target position.

6. A control unit for controlling a motor for use in a printer, as set forth in claim 5, wherein the target position modifying and calculating part includes:

an error calculating part to calculate an error of the feed-amount of the printing medium at the previous motor start-up based on a target value of a control amount at a previous motor start-up and the position detected by the position detecting part just before the present motor start-up; and

an adder to add the target value of a feed-amount of the printing medium at the present motor start-up and the error.

7. A control unit for controlling a motor for use in a printer, as set forth in claim 6, wherein the position detecting part is a position counter to count output pulses of an encoder that rotates to follow rotation of the motor, and the target position modifying and calculating part further includes a reset signal generating part to generate a reset signal for resetting a counted value of the position counter.

8. A control unit for controlling a motor for use in a printer, as set forth in claim 5, wherein the printing medium is a paper and the motor is a paper-feed motor.

9. A control unit for controlling a motor for use in a printer, as set forth in claim 5, wherein the position control part performs PID control.

10. A control method of controlling a motor for use in a printer comprising the steps of:

counting output pulses of an encoder that rotates to follow rotation of the motor and detecting a position of a printing medium transferred by the motor by a position counter;

calculating an modified target value of a feed-amount of the printing medium based on a target value of a feed-amount of the printing medium and a previous stop position of the printing medium detected by the position counter, and setting a counted value of the position counter to the modified target value; and

controlling the motor so that the counted value of the position counter falls into a predetermined range including zero.

11. A control method of controlling a motor for use in a printer, as set forth in claim 10, wherein the printing medium is a paper and the motor is a paper-feed motor.

12. A control method of controlling a motor for use in a printer, as set forth in claim 10, wherein the step of controlling performs PID control.

13. A control method of controlling a motor for use in a printer, as set forth in claim 10, wherein the position counter counts-up or counts-down the output pulses according a normal or reverse rotation of the motor.

14. A method of controlling a motor for use in a printer comprising the steps of:

detecting a position of a printing medium transferred by the motor;

calculating a modified target position value of the printing medium based on a target value of a feed-amount of the printing medium at the present motor start-up, another target value of a feed-amount of the printing medium at a previous motor start-up, and a position of the printing medium detected just before the present motor start-up; and

controlling the motor based on positional deviation of the position detected by the position detecting part from the modified target position.

15. A control method of controlling a motor for use in a printer, as set forth in claim 14, wherein the step of calculating the modified target position includes the steps of:

calculating an error of the feed-amount of the printing medium at the previous motor start-up based on the target value of the a feed-amount of the printing medium at the previous motor start-up and the position detected by the position detecting part just before the present motor start-up; and

adding the target value of the feed-amount of the printing medium at the present motor start-up and the error.

16. A processor readable medium storing program code for causing a computer to control a motor for use in a printer comprising:

first program code means for, by a position counter, counting output pulses of an encoder that rotates to follow rotation of the motor to detect a position of a printing medium transferred by the motor;

second program code means for modifying and calculating part to calculate an modified target value of a feed-amount of the printing medium based on a target value of a feed-amount of the printing medium and a previous stop position of the printing medium detected by the position counter, and setting a counted value of the position counter to the modified target value; and

third program code means for controlling the motor so that the counted value of the position counter falls into a predetermined range including zero.

17. A processor readable medium storing program code for causing a computer to control a motor for use in a printer comprising:

first program code means for detecting a position of a printing medium transferred by the motor;

second program code means for calculating a modified target position of the printing medium based on a target value of a feed-amount of the printing medium at the present motor start-up,

another target value of a feed-amount of the printing medium at a previous motor start-up, and a position of the printing medium detected just before the present motor start-up; and

third program code means for controlling the motor based on positional deviation of the detected position of the printing medium from the modified target position.

18. A control unit for controlling a motor for use in a printer comprising:

a position counter to detect a position of a sheet of paper transferred by a paper-feed motor based on output pulses of an encoder that rotates to follow rotation of the paper-feed motor;

a driving part to apply a current value to the paper-feed motor based on a target value of a feed-amount of the sheet of paper and an output of the position counter, to drive the paper-feed motor;

a current value signal generating part to determine whether the absolute value of deviation of the output of the position counter from the target value of the feed-amount of the sheet of paper falls in the range of a first predetermined value to a second predetermined value smaller than the first predetermined value during stoppage of the paper-feed motor, to generate a current value signal, when the absolute value of deviation falls in the range, so that the deviation becomes zero,

wherein the driving part drives the paper-feed motor based on the current value signal.

19. A control unit for controlling a motor for use in a printer, as set forth in claim 18 further comprising a paper delivery part for performing a paper delivery operation, wherein the current value signal generating part feeds a paper delivery command to the paper delivery part when the absolute value of deviation is larger than the first predetermined value, thus the paper delivery part performs the paper delivery operation.

20. A control unit for controlling a motor for use in a printer, as set forth in claim 18, wherein the driving part includes a

PID control part.

21. A control method of controlling a motor for use in a printer comprising the steps of:

obtaining deviation, while a paper-feed motor is stopping, of an actual feed-amount of a sheet of paper calculated based on output pulses of an encoder that rotates to follow rotation of a paper-feed motor from a target feed-amount of the sheet of paper at a previous motor start-up;

determining whether the absolute value of the deviation falls in the range of a first predetermined value and a second predetermined value smaller than the first predetermined value;

generating a current value signal so that the deviation becomes zero when the absolute value falls in the range; and controlling the paper-feed motor based on the current value signal.

22. A control method of controlling a motor for use in a printer, as set forth in claim 20 further comprising the step of performing a paper delivery operation when the absolute value of the deviation is larger than the first predetermined value.

23. A processor readable medium storing program code for causing a computer to control a motor for use in a printer comprising the steps of:

first program code means for obtaining deviation, while a paper-feed motor is stopping, of an actual feed-amount of a sheet of paper calculated based on output pulses of an encoder that rotates to follow rotation of a paper-feed motor from a target feed-amount of the sheet of paper at a previous motor start-up;

second program code means for determining whether the absolute value of the deviation falls in the range of a first predetermined value and a second predetermined value smaller than the first predetermined value;

third program code means for generating a current value signal so that the deviation becomes zero when the absolute value

falls into the range ; and

fourth program code means for controlling the paper-feed motor based on the current value signal.

100
101
102
103
104
105
106
107
108
109
110
111
112
113
114
115
116
117
118
119
120
121
122
123
124
125
126
127
128
129
130
131
132
133
134
135
136
137
138
139
140
141
142
143
144
145
146
147
148
149
150
151
152
153
154
155
156
157
158
159
160
161
162
163
164
165
166
167
168
169
170
171
172
173
174
175
176
177
178
179
180
181
182
183
184
185
186
187
188
189
190
191
192
193
194
195
196
197
198
199
200
201
202
203
204
205
206
207
208
209
210
211
212
213
214
215
216
217
218
219
220
221
222
223
224
225
226
227
228
229
230
231
232
233
234
235
236
237
238
239
240
241
242
243
244
245
246
247
248
249
250
251
252
253
254
255
256
257
258
259
260
261
262
263
264
265
266
267
268
269
270
271
272
273
274
275
276
277
278
279
280
281
282
283
284
285
286
287
288
289
290
291
292
293
294
295
296
297
298
299
300
301
302
303
304
305
306
307
308
309
310
311
312
313
314
315
316
317
318
319
320
321
322
323
324
325
326
327
328
329
330
331
332
333
334
335
336
337
338
339
340
341
342
343
344
345
346
347
348
349
350
351
352
353
354
355
356
357
358
359
360
361
362
363
364
365
366
367
368
369
370
371
372
373
374
375
376
377
378
379
380
381
382
383
384
385
386
387
388
389
390
391
392
393
394
395
396
397
398
399
400
401
402
403
404
405
406
407
408
409
410
411
412
413
414
415
416
417
418
419
420
421
422
423
424
425
426
427
428
429
430
431
432
433
434
435
436
437
438
439
440
441
442
443
444
445
446
447
448
449
450
451
452
453
454
455
456
457
458
459
460
461
462
463
464
465
466
467
468
469
470
471
472
473
474
475
476
477
478
479
480
481
482
483
484
485
486
487
488
489
490
491
492
493
494
495
496
497
498
499
500
501
502
503
504
505
506
507
508
509
510
511
512
513
514
515
516
517
518
519
520
521
522
523
524
525
526
527
528
529
530
531
532
533
534
535
536
537
538
539
540
541
542
543
544
545
546
547
548
549
550
551
552
553
554
555
556
557
558
559
560
561
562
563
564
565
566
567
568
569
570
571
572
573
574
575
576
577
578
579
580
581
582
583
584
585
586
587
588
589
590
591
592
593
594
595
596
597
598
599
600
601
602
603
604
605
606
607
608
609
610
611
612
613
614
615
616
617
618
619
620
621
622
623
624
625
626
627
628
629
630
631
632
633
634
635
636
637
638
639
640
641
642
643
644
645
646
647
648
649
650
651
652
653
654
655
656
657
658
659
660
661
662
663
664
665
666
667
668
669
670
671
672
673
674
675
676
677
678
679
680
681
682
683
684
685
686
687
688
689
690
691
692
693
694
695
696
697
698
699
700
701
702
703
704
705
706
707
708
709
710
711
712
713
714
715
716
717
718
719
720
721
722
723
724
725
726
727
728
729
730
731
732
733
734
735
736
737
738
739
740
741
742
743
744
745
746
747
748
749
750
751
752
753
754
755
756
757
758
759
760
761
762
763
764
765
766
767
768
769
770
771
772
773
774
775
776
777
778
779
780
781
782
783
784
785
786
787
788
789
790
791
792
793
794
795
796
797
798
799
800
801
802
803
804
805
806
807
808
809
810
811
812
813
814
815
816
817
818
819
820
821
822
823
824
825
826
827
828
829
830
831
832
833
834
835
836
837
838
839
840
841
842
843
844
845
846
847
848
849
850
851
852
853
854
855
856
857
858
859
860
861
862
863
864
865
866
867
868
869
870
871
872
873
874
875
876
877
878
879
880
881
882
883
884
885
886
887
888
889
890
891
892
893
894
895
896
897
898
899
900
901
902
903
904
905
906
907
908
909
910
911
912
913
914
915
916
917
918
919
920
921
922
923
924
925
926
927
928
929
930
931
932
933
934
935
936
937
938
939
940
941
942
943
944
945
946
947
948
949
950
951
952
953
954
955
956
957
958
959
960
961
962
963
964
965
966
967
968
969
970
971
972
973
974
975
976
977
978
979
980
981
982
983
984
985
986
987
988
989
990
991
992
993
994
995
996
997
998
999
1000
1001
1002
1003
1004
1005
1006
1007
1008
1009
1010
1011
1012
1013
1014
1015
1016
1017
1018
1019
1020
1021
1022
1023
1024
1025
1026
1027
1028
1029
1030
1031
1032
1033
1034
1035
1036
1037
1038
1039
1040
1041
1042
1043
1044
1045
1046
1047
1048
1049
1050
1051
1052
1053
1054
1055
1056
1057
1058
1059
1060
1061
1062
1063
1064
1065
1066
1067
1068
1069
1070
1071
1072
1073
1074
1075
1076
1077
1078
1079
1080
1081
1082
1083
1084
1085
1086
1087
1088
1089
1090
1091
1092
1093
1094
1095
1096
1097
1098
1099
1100
1101
1102
1103
1104
1105
1106
1107
1108
1109
1110
1111
1112
1113
1114
1115
1116
1117
1118
1119
1120
1121
1122
1123
1124
1125
1126
1127
1128
1129
1130
1131
1132
1133
1134
1135
1136
1137
1138
1139
1140
1141
1142
1143
1144
1145
1146
1147
1148
1149
1150
1151
1152
1153
1154
1155
1156
1157
1158
1159
1160
1161
1162
1163
1164
1165
1166
1167
1168
1169
1170
1171
1172
1173
1174
1175
1176
1177
1178
1179
1180
1181
1182
1183
1184
1185
1186
1187
1188
1189
1190
1191
1192
1193
1194
1195
1196
1197
1198
1199
1200
1201
1202
1203
1204
1205
1206
1207
1208
1209
1210
1211
1212
1213
1214
1215
1216
1217
1218
1219
1220
1221
1222
1223
1224
1225
1226
1227
1228
1229
1230
1231
1232
1233
1234
1235
1236
1237
1238
1239
1240
1241
1242
1243
1244
1245
1246
1247
1248
1249
1250
1251
1252
1253
1254
1255
1256
1257
1258
1259
1260
1261
1262
1263
1264
1265
1266
1267
1268
1269
1270
1271
1272
1273
1274
1275
1276
1277
1278
1279
1280
1281
1282
1283
1284
1285
1286
1287
1288
1289
1290
1291
1292
1293
1294
1295
1296
1297
1298
1299
1300
1301
1302
1303
1304
1305
1306
1307
1308
1309
1310
1311
1312
1313
1314
1315
1316
1317
1318
1319
1320
1321
1322
1323
1324
1325
1326
1327
1328
1329
1330
1331
1332
1333
1334
1335
1336
1337
1338
1339
1340
1341
1342
1343
1344
1345
1346
1347
1348
1349
1350
1351
1352
1353
1354
1355
1356
1357
1358
1359
1360
1361
1362
1363
1364
1365
1366
1367
1368
1369
1370
1371
1372
1373
1374
1375
1376
1377
1378
1379
1380
1381
1382
1383
1384
1385
1386
1387
1388
1389
1390
1391
1392
1393
1394
1395
1396
1397
1398
1399
1400
1401
1402
1403
1404
1405
1406
1407
1408
1409
1410
1411
1412
1413
1414
1415
1416
1417
1418
1419
1420
1421
1422
1423
1424
1425
1426
1427
1428
1429
1430
1431
1432
1433
1434
1435
1436
1437
1438
1439
1440
1441
1442
1443
1444
1445
1446
1447
1448
1449
1450
1451
1452
1453
1454
1455
1456
1457
1458
1459
1460
1461
1462
1463
1464
1465
1466
1467
1468
1469
1470
1471
1472
1473
1474
1475
1476
1477
1478
1479
1480
1481
1482
1483
1484
1485
1486
1487
1488
1489
1490
1491
1492
1493
1494
1495
1496
1497
1498
1499
1500
1501
1502
1503
1504
1505
1506
1507
1508
1509
1510
1511
1512
1513
1514
1515
1516
1517
1518
1519
1520
1521
1522
1523
1524
1525
1526
1527
1528
1529
1530
1531
1532
1533
1534
1535
1536
1537
1538
1539
1540
1541
1542
1543
1544
1545
1546
1547
1548
1549
1550
1551
1552
1553
1554
1555
1556
1557
1558
1559
1560
1561
1562
1563
1564
1565
1566
1567
1568
1569
1570
1571
1572
1573
1574
1575
1576
1577
1578
1579
1580
1581
1582
1583
1584
1585
1586
1587
1588
1589
1590
1591
1592
1593
1594
1595
1596
1597
1598
1599
1600
1601
1602
1603
1604
1605
1606
1607
1608
1609
1610
1611
1612
1613
1614
1615
1616
1617
1618
1619
1620
1621
1622
1623
1624
1625
1626
1627
1628
1629
1630
1631
1632
1633
1634
1635
1636
1637
1638
1639
1640
1641
1642
1643
1644
1645
1646
1647
1648
1649
1650
1651
1652
1653
1654
1655
1656
1657
1658
1659
1660
1661
1662
1663
1664
1665
1666
1667
1668
1669
1670
1671
1672
1673
1674
1675
1676
1677
1678
1679
1680
1681
1682
1683
1684
1685
1686
1687
1688
1689
1690
1691
1692
1693
1694
1695
1696
1697
1698
1699
1700
1701
1702
1703
1704
1705
1706
1707
1708
1709
1710
1711
1712
1713
1714
1715
1716
1717
1718
1719
1720
1721
1722
1723
1724
1725
1726
1727
1728
1729
1730
1731
1732
1733
1734
1735
1736
1737
1738
1739
1740
1741
1742
1743
1744
1745
1746
1747
1748
1749
1750
1751
1752
1753
1754
1755
1756
1757
1758
1759
1760
1761
1762
1763
1764
1765
1766
1767
1768
1769
1770
1771
1772
1773
1774
1775
1776
1777
1778
1779
1780
1781
1782
1783
1784
1785
1786
1787
1788
1789
1790
1791
1792
1793
1794
1795
1796
1797
1798
1799
1800
1801
1802
1803
1804
1805
1806
1807
1808
1809
1810
1811
1812
1813
1814
1815
1816
1817
1818
1819
1820
1821
1822
1823
1824
1825
1826
1827
1828
1829
1830
1831
1832
1833
1834
1835
1836
1837
1838
1839
1840
1841
1842
1843
1844
1845
1846
1847
1848
1849
1850
1851
1852
1853
1854
1855
1856
1857
1858
1859
1860
1861
1862
1863
1864
1865
1866
1867
1868
1869
1870
1871
1872
1873
1874
1875
1876
1877
1878
1879
1880
1881
1882
1883
1884
1885
1886
1887
1888
1889
1890
1891
1892
1893
1894
1895
1896
1897
1898
1899
1900
1901
1902
1903
1904
1905
1906
1907
1908
1909
1910
1911
1912
1913
1914
1915
1916
1917
1918
1919
1920
1921
1922
1923
1924
1925
1926
1927
1928
1929
1930
1931
1932
1933
1934
1935
1936
1937
1938
1939
1940
1941
1942
1943
1944
1945
1946
1947
1948
1949
1950
1951
1952
1953
1954
1955
1956
1957
1958
1959
1960
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
2037
2038
2039
2040
2041
2042
2043
2044
2045
2046
2047
2048
2049
2050
2051
2052
2053
2054
2055
2056
2057
2058
2059
2060
2061
2062
2063
2064
2065
2066
2067
2068
2069
2070
2071
2072
2073
2074
2075
2076
2077
2078
2079
2080
2081
2082
2083
2084
2085
2086
2087
2088
2089
2090
2091
2092
2093
2094
2095
2096
2097
2098
2099
2100
2101
2102
2103
2104
2105
2106
2107
2108
2109
2110
2111
2112
2113
2114
2115
2116
2117
2118
2119
2120
2121
2122
2123
2124
2125
2126
2127
2128
2129
2130
2131
2132
2133
2134
2135
2136
2137
2138
2139
2140
2141
2142
2143
2144
2145
2146
2147
2148
2149
2150
2151
2152
2153
2154
2155
2156
2157
2158
2159
2160
2161
2162
2163
2164
2165
2166
2167
2168
2169
2170
2171
2172
2173
2174
2175
2176
2177
2178
2179
2180
2181
2182
2183
2184
2185
2186
2187
2188
2189
2190
2191
2192
2193
2194
2195
2196
2197
2198
2199
2200
2201
2202
2203
2204
2205
2206
2207
2208
2209
2210
2211
2212
2213
2214
2215
2216
2217
2218
2219
2220
2221
2222
2223
2224
2225
2226
2227
2228
2229
2230
2231
2232
2233
2234
2235
2236
2237
2238
2239
2240
2241
2242
2243
2244
2245
2246
2247
2248
2249
2250
2251
2252
2253
2254
2255
2256
2257
2258
2259
2260
2261
2262
2263
2264
2265
2266
2267
2268
2269
2270
2271
2272
2273
2274
2275
2276
2277
2278
2279
2280
2281
2282
2283
2284
2285
2286
2287
2288
2289

ABSTRACT OF THE DISCLOSURE

There is provided precise paper feeding. A control unit for controlling a motor for use in a printer includes a position counter to count output pulses of an encoder that rotates to follow rotation of the motor and detect a position of a printing medium transferred by the motor; a target control amount modifying and calculating part to calculate a modified target value of a feed-amount of the printing medium based on a target value of a feed-amount of the printing medium and a previous stop position of the printing medium detected by the position counter, and set a counted value of the position counter to the modified target value; and a position control part to control the motor so that the counted value of the position counter falls into a predetermined range including zero.

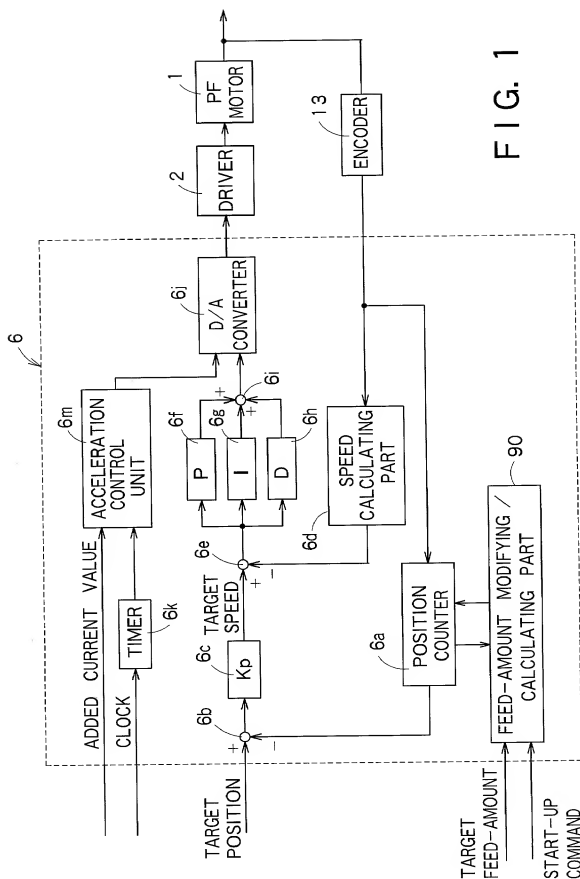


FIG. 1

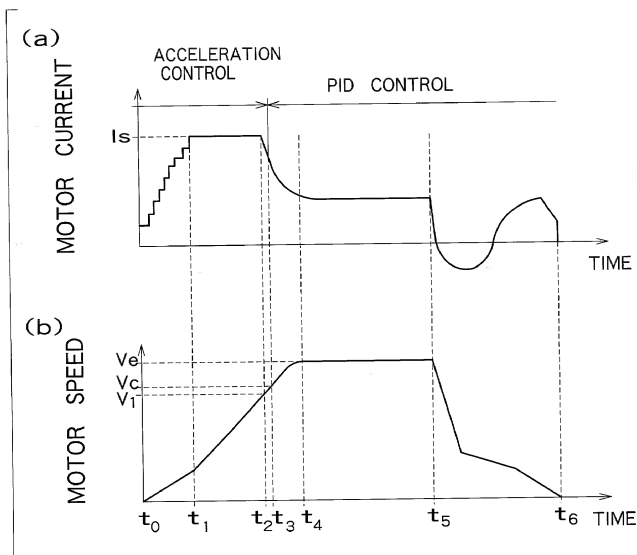
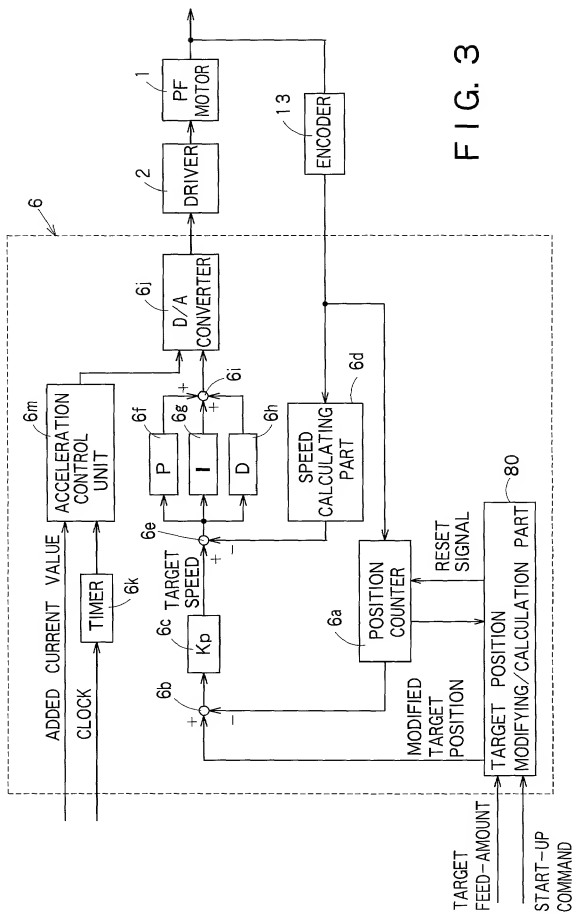


FIG. 2



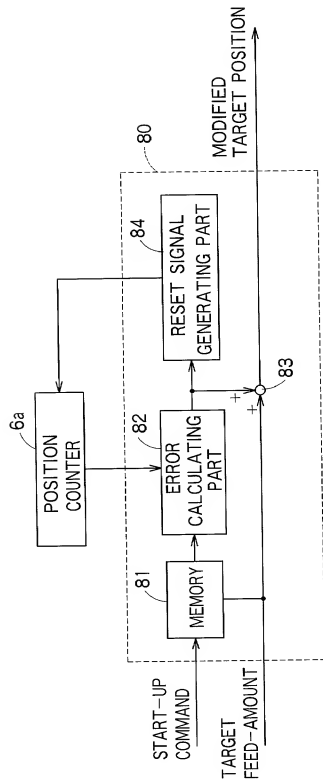


FIG. 4

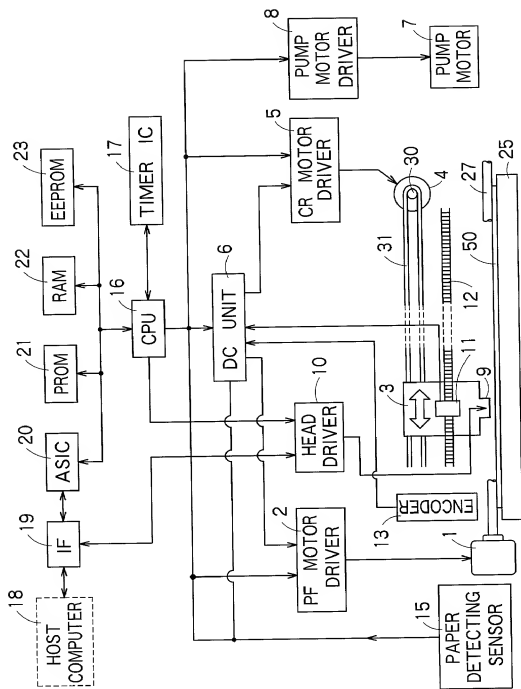


FIG. 5

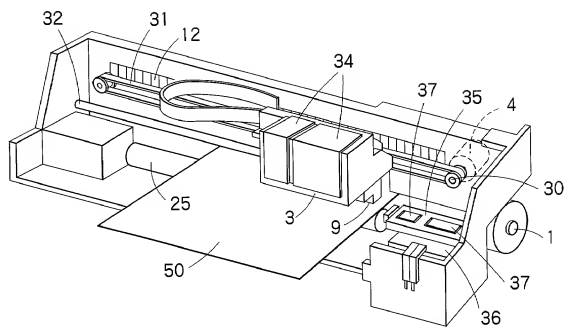


FIG. 6

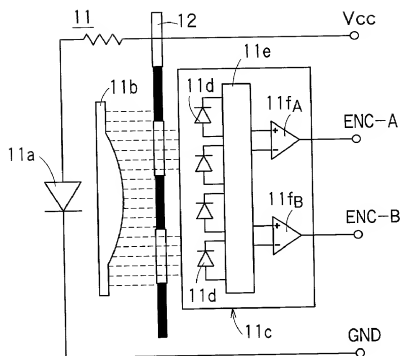


FIG. 7

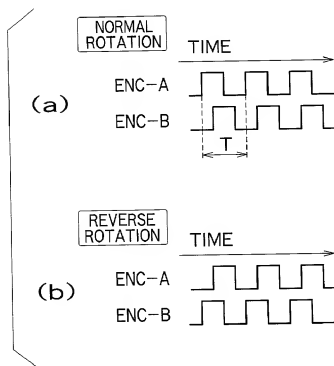


FIG. 8

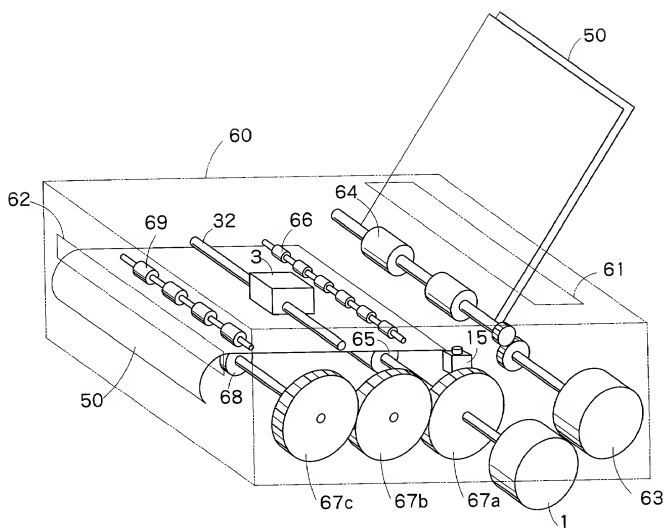


FIG. 9

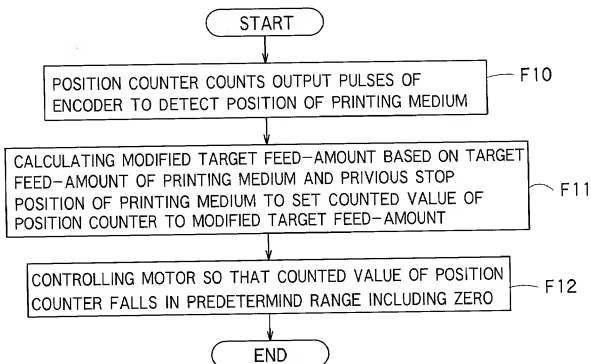


FIG. 10

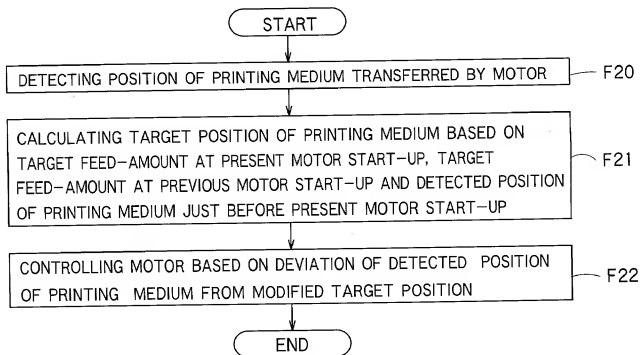


FIG. 11

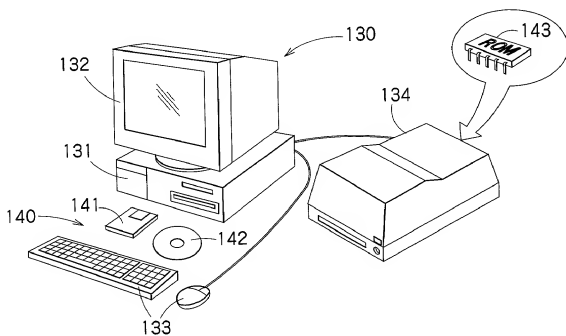


FIG. 12

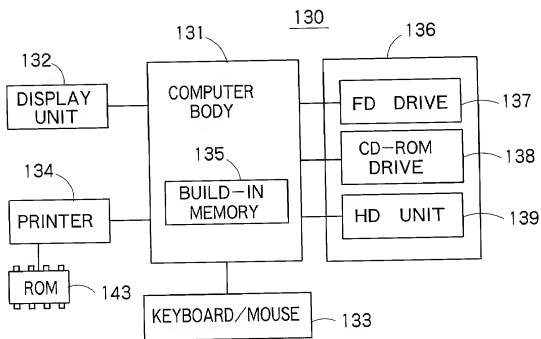


FIG. 13

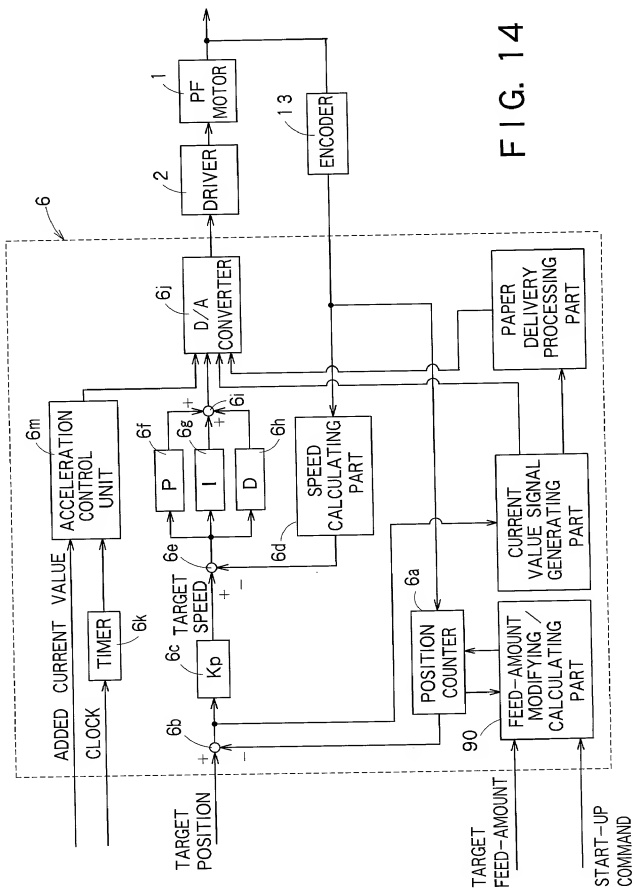


FIG. 14

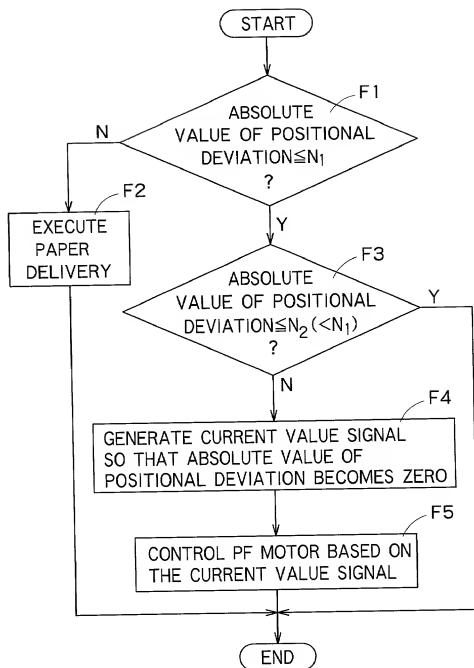


FIG. 15

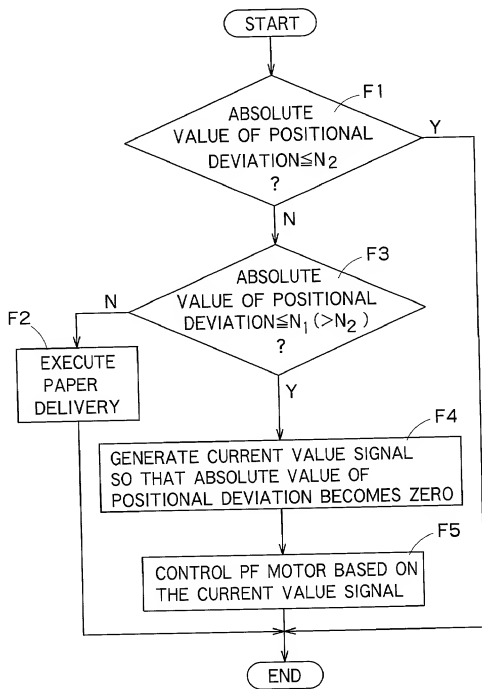


FIG. 16